

Model User Manual

CSU Uncompahgre Basin Selenium and Total Dissolved Solids Model

CSU_Uncomp_se_tds_model.xls

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Introduction

Elevated selenium concentrations have been observed in several rivers in the western United States and are a concern for healthy aquatic systems. Water quality modeling is a valuable tool for quantifying the importance of sources and assessing management alternatives for stream standards compliance in basins with impaired water quality. This model uses a relatively simple approach to describe the water distribution system and processes that drive loading of dissolved selenium and salts from the naturally occurring Cretaceous shale soils in the extensively irrigated Uncompahgre Basin in western Colorado.

A mass balance approach is utilized to describe all the flow components of the agriculture system in the basin on a monthly timestep. Two-component mixing models are used to describe constituent transfer from irrigated sub-basins to major tributaries in the Basin. Calibrated model output characterizes processes that load an average total of 4,130 kg (9,100 lbs) of selenium and 2.9×10^8 kg (316,000 tons) of salts per year from agricultural sub-basins to the Uncompahgre River. Simulations of Best Management Practices to minimize seepage and constituent loading predict that extensive implementation would be required to reduce selenium concentrations to comply with current water quality standards.

The model implemented in Microsoft Excel described here contains the functionality for prediction of flow, dissolved selenium concentration (Se) and total dissolved solids concentration (TDS) at a monthly timestep. This model spreadsheet also contains the modeling input data, parameter values and historical water quality data for the calibration time period of water years 1991 – 1996 and the validation time period of water years 1997 – 2000. The model output for the historical baseline simulation of October 1990 - September 2003 is also included. Model predictions for several implementations of Best Management Practices (BMP's) are also included in the modeling spreadsheet.

This brief document describes the general model structure, user interface and methods for running simulations only. For a complete description of the modeling study, methods and results see Hanna (2005) or Hanna and Loftis (submitted 2005).

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Model Software

The overall model structure is divided into three models for: flow, Se and TDS. The model calculations are performed by a combination of Excel spreadsheet functions and macros coded in Visual Basic for Applications. Cells in the *flow_output*, *se_output* and *TDS_output* sheets are updated by macro code, model calculations are performed by cell formulas and model output retrieved and organized by macros following calculation. Model output is placed in spreadsheet cells for calculation of Se load, TDS load, 85th percentile of Se concentration for water quality standards compliance, irrigation and non-irrigation season grouping and for time series plotting.

Data and Parameters

Model input data describing the time series of hydrologic conditions are provided in the spreadsheet. Calibrated model parameters and physical modeling data describing representative meteorological conditions and the irrigated agriculture system in the Uncompahgre Basin are also included in the model. Many modeling data values are exposed to the user directly or indirectly in code to allow for new synthetic BMP simulations to be performed by the user.

Hydrologic data for the Uncompahgre and Gunnison Rivers as well as monthly diversion volumes throughout the Uncompahgre Basin (CWCB and DWR 2004) are included in the *monthly_flow_data* and *input_flow_data* sheets.

Water Quality sampling data throughout the Uncompahgre River and tributaries (USGS 2003) is included for comparison in the *water_quality_data* sheet.

Physical data describing irrigated parcel areas, lengths of canals and laterals and areas of ponds in sub-basins for the calibrated model are described in the *model_parameters* and *model_data* sheets.

Hydrologic components of the agricultural system such as precipitation, evaporation, crop consumptive use for the calibration simulation are described in the *model_data* sheet.

Calibrated model parameters for seepage, flow balance partitioning and convolution and concentrations for constituent transfer models are presented in the *model_parameters* sheet.

Running the Model

To run the model macros must be enabled. The Analysis Toolpack and the Analysis Toolpack – VBA add-ins must be available.

By default, the model is setup to run the historical baseline simulation. The model is run by hitting the “**Run Model**” button in the *flow_output* sheet. For the baseline simulation of monthly timesteps for 14 years, a model run may take over 10 minutes. Excel is unable to perform additional tasks during model simulation and only refreshes its display completely, every ten model iterations.

To ensure proper release of groundwater storage to return flows during winter, a one year “spin up” period is required for the model. Start the model in an October, one year before the period of interest.

Types of Model Output

Model output values for the current simulation are placed in many sheets: *model_output*, *all_output*, *sub-basin_output*, *flow_output*, *se_output*, *TDS_output*, *Se_load*, *TDS_load*, *irr_season_output* and *nonirr_season_output*. Time series plots of some of the most important output are presented in the *model_plots* sheet.

Metrics of goodness of fit to measure data are calculated for the current model run in the *calibration* sheet. Comparison plots are also included in this sheet. Computations and plots of calendar month averages for flow and water quality for both model predictions and measured data can be created in the *cal_month_output* sheet. The time period number for averaging, the sub-basin number and the constituent number are entered and the “Calculate” button is used for automated plot update.

Simulating a BMP

Adjustments to the model parameters and model values are performed in the *model_parameters* and *model_data* sheets. For BMP simulations presented in Hanna (2005) and Hanna and Loftis (submitted 2005), calibration parameters describing flow partition and convolution and sub-basin geochemical parameters were not adjusted to simulate BMP’s. Instead, values such as canal and lateral length, irrigated parcel acreage, irrigation efficiencies and diversion volumes were adjusted. Several BMP-specific switch values are available at the bottom of the *model_parameters* sheet.

After adjusting model values in order to synthetically alter the Uncompahgre Basin’s irrigated agriculture characteristics, run the full baseline simulation (months 481-648) by hitting the “Run Model” button on the *flow_output* sheet.

BMP simulation output can be compared against the baseline simulation in many ways: pre-built time series plots of the current model run versus the baseline simulation are available in the *model_plots* sheet. Calculations of the longitudinal 85th percentile of [Se] as well as the longitudinal average flow are available in the *BMPs* worksheet. Calculation of these attributes for the baseline and many previously-run BMP simulations are also available in the *BMPs* worksheet, plots are available in the *BMP_fig1* and *BMP_fig2* sheets.

Disclaimer

Given the nature of spreadsheet modeling, errors in cell functions are easily introduced that can disrupt proper model functioning. Any introduced errors in cell values or formulas are often difficult to find to fix. Before adjusting model values for BMP simulation, save a copy of the entire spreadsheet containing the calibrated baseline simulation parameters and output for reference.

References

Colorado Water Conservation Board and Division of Water Resources (2004). "Colorado Decision Support System." Hydrobase database, StateCU model and GIS data products, <<http://cdss.state.co.us>> (11/10/2004).

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